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Psychometric validation of the Perceived Stress Scale (PSS-10) among family caregivers of persons with schizophrenia in China

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2023-076372
Article Type:	Original research
Date Submitted by the Author:	06-Jun-2023
Complete List of Authors:	Tao, Xiao ; Central South University Third Xiangya Hospital Zhu, Feng ; Central South University Xiangya School of Public Health Wang, Dan ; Central South University Xiangya School of Public Health Liu, Xiang ; Central South University Xiangya School of Public Health Xi, Shi-jun; Central South University Xiangya School of Public Health, Department of Social Medicine and Health Management; Foshan Center for Disease Control and Prevention YU, YU; Xiangya Hospital Central South University, ; Yale University School of Medicine, Division of Prevention and Community Research
Keywords:	Psychometrics, PSYCHIATRY, Schizophrenia & psychotic disorders < PSYCHIATRY, Nursing Care

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Title Page

Title: Psychometric validation of the Perceived Stress Scale (PSS-10) among family caregivers of persons with schizophrenia in China

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Abstract

Background: The 10-item Perceived Stress Scale (PSS-10) is a widely used measure of perceived stress that has been validated in various populations. The present study examines the reliability and validity of the PSS-10 in a population not previously examined: Chinese family caregivers of persons with schizophrenia.

Methods: A sample of 449 family caregivers of persons with schizophrenia were recruited for psychometric testing of the scale. Internal consistency was tested by calculating Cronbach's α , and test-retest reliability using the intraclass correlation coefficient (ICC). Factor structure was tested using confirmatory factor analysis (CFA), and concurrent validity was examined by investigating the correlation of the PSS-10 to relevant convergent and discriminant measures, including stigma, depression, anxiety, social support, family functioning and caregiving rewarding feelings.

Results: The PSS-10 showed good internal consistency and test-retest reliability, with Cronbach's alpha of 0.79 and ICC of 0.91, respectively. CFA corroborated its priori two-factor structure. In addition, the PSS-10 was correlated in the expected direction with all indicators examined; that is, positively correlated with stigma ($r=0.16$, $p<0.01$), depression ($r=0.54$, $p<0.01$), and anxiety ($r=0.62$, $p<0.01$), and negatively correlated with social support ($r=-0.22$, $p<0.01$), family functioning ($r=-0.30$, $p<0.01$), and caregiving rewarding feelings ($r=-0.33$, $p<0.01$), indicating strong concurrent validity.

Conclusion: The findings indicate that the PSS-10 can be used to measure perceived stress in future research and practice with this and related populations.

Keywords: Perceived Stress Scale; psychometric testing; reliability, validity,

Confirmatory Factor Analysis

Strengths and limitations of this study

1. This study validated the Chinese version of PSS-10 among family caregivers of persons with schizophrenia. Its psychometric properties among family caregivers of individuals with prolonged illnesses, such as with schizophrenia, has not been examined in Chinese communities before.
2. High test–retest reliability was supported by high ICC of the total score, also showing the stability of PSS-10 in assessing perceived stress over time.
3. The sample were recruited from 12 urban communities of Changsha city and thus may not representative of other areas, especially rural communities.
4. The cross-sectional design of the study may preclude testing of sensitivity to change for the PSS-10.

Psychometric validation of the Perceived Stress Scale (PSS-10) among family caregivers of persons with schizophrenia in China

Introduction

Schizophrenia is a severe, debilitating chronic psychiatric disorder that causes impairments in cognition, speech, thinking and emotional responsiveness.[1] It impairs individuals' ability to carry out daily activities, including social and occupational functioning [2]. For instance, Wiersma et al. (2000) conducted a 15-year multicenter survey in Europe and found that social dysfunction is widespread and persistent in schizophrenia [3]. Similar findings were also reported in China[4]. Consequently, people with schizophrenia often require ongoing support and care, which in many Asian countries, is often provided by family members [5]. In China, efforts have been made to establish community-based rehabilitation services for individuals with schizophrenia but with family members assuming the major role of caregiving [6]. Caring for people with schizophrenia can be a demanding activity that challenges the physical and mental health of family caregivers [7]. As a result, family caregivers may report a high level of stress, which can lead to negative health outcomes and reduced quality of life [8].

Studies have shown that the stress experienced by family caregivers of people with schizophrenia is higher than for caregivers of people with other prolonged illnesses, which is related to higher psychological distress, depression, and anxiety [9, 10]. Caregivers' stress may also result in conflict among family members and increased family dysfunction [7, 11]. These caregivers also report increased perceived stigma due

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4 to their loved one's mental illness [12-14] as well as insufficient social support [12].
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6 For example, family caregivers may report shame due to disruptive public behaviors of
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8 the family member with schizophrenia and seek to hide them from the public as much
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10 as possible [15, 16]. This can result in social isolation, lack of social support, and social
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12 exclusion, which may result in increased stress. Thus, it is critical that the perceived
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14 stress of family caregivers of persons with schizophrenia be assessed using reliable and
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16 valid measures.
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22 The perceived stress scale (PSS) is one of the most widely used measure for assessing
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24 perceived stress in the world [17, 18]. The PSS [17], measures the degree to which
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26 participants perceive unpredictability, lack of control, or overload in their lives [19]. The
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28 original PSS included 14 items (PSS-14), which were further abbreviated into two short
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30 versions: PSS-10 and PSS-4 [17, 19]. Although the original PSS-14 showed sufficient
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32 validity and reliability, the shorter version (PSS-10) has superior psychometric
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34 properties and is recommended for research [20]. The PSS-10 has been translated into
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36 various languages and validated in various countries, such as Sweden [21], France [22],
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38 Korea [23], Mexico [24], the United States [25], Arabia [26], Serbia [27], Germany [28],
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40 Viet Nam [29], Brazil [30] and Thailand [31]. The PSS -10 was first translated into
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42 Simplified Chinese (the language of the Chinese mainland) by Yang and Huang in 2003
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44 [32], and approved by its original developer Dr. Cohen [33]. The Simplified Chinese
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46 version of the PSS-10 (C-PSS-10) has been used with including university students [34],
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48 elderly service workers [35] and cardiac patients [36], but its psychometric properties
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50 among family caregivers of individuals with prolonged illnesses, such as with
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4 schizophrenia, has not been examined in Chinese communities.
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6 The current study was thus conducted to validate the PSS-10 among a Chinese
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8 community sample of family caregivers of people living with schizophrenia.
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10 Specifically, we examine psychometric properties of PSS-10 for internal consistency
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12 reliability, test-retest reliability, factor structure and concurrent validity.
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19 **Materials and methods**

20 **Participants and procedure**

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22 This cross-sectional study used baseline data from a large community sample who
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24 agreed to participate in an intervention to support family caregivers of persons with
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26 schizophrenia [37]. A total of 449 family caregivers of people with schizophrenia were
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28 recruited from 12 communities affiliated with the Changsha Psychiatric Hospital
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30 through the "686 program". "686 program" is China's largest demonstration project
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32 aimed at integrating hospital and community services for serious mental illness [38].
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34 The Changsha Psychiatric Hospital has long provided mental health services to the 12
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36 communities, including free antipsychotic medicine delivery. Every month, a medical
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38 team from the Changsha Psychiatric Hospital went to each community health center to
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40 distribute free medicine and run routine health check-ups for registered clients with
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42 serious mental illness. Inclusion criteria of family caregivers are: 1) caring for a family
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44 member registered in the "686 program" and satisfied the Chinese classification of
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46 Mental Disorders (CCMD-3) or the international classification of Schizophrenia (ICD-
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48 10) criteria for schizophrenia ; 2) living with the care recipient for at least the last two
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4 years; 3) aged ≥ 18 years; 4) able to read and communicate and complete the
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6 questionnaire. Exclusion criteria include: 1) care recipient not registered in the 686
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8 program; 2) care recipient diagnosed with a mental illness other than schizophrenia,
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10 such as depression and epilepsy; 3) care recipient living alone; 4) family caregiver has
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12 a serious physical or mental illness and thus unable to communicate and complete the
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14 interview; 5) family caregiver younger than 18 years. Our final sample size was 449
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16 participants, satisfying the sample size requirement of at least 10 participants for each
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18 item in psychometric testing of scales [39].
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25 Data collection was conducted from May 2019 and September 2019. Family
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27 caregivers were approached during the free medicine delivery process by the medical
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29 team and invited to participate in the study. The medical team explained in detail about
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31 the study and referred interested caregivers to our research team. The research team
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33 fully explained the research to each family caregiver and fully informed the benefits
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35 and risk of participation, as well as their right to withdraw at any time. After providing
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37 written informed consent, the caregivers received face-to-face interviews conducted by
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39 our research team, and completed a battery of questionnaires. The entire interview
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41 required 20-40 minutes, and each participant were reimbursed with RMB 20 yuan (USD
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43 \$2.80) for completion of the questionnaire.
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53 Instruments

54 Perceived stress scale (PSS-10)

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56 The 10-item perceived stress scale (PSS-10) is a self-assessed measure of
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4 psychological stress experienced over the past 30 days. Each answer is scored on a
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6 Likert-type scale of 5, ranging from 0 (never) to 4 (very often) .The scale included two
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8 factors [40, 41] [42]: “perceived helplessness” consists of 6 negative items (item
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10 1,2,3,6,9,10) assessing the degree of lack of control and negative reactions; “perceived
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12 self-efficacy” consists of 4 positive items (item 4,5,7, 8) assessing one’s ability to cope
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14 with existing stressors [19, 36, 43]. which were reverse coded so that higher score
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16 indicating higher stress. The total score of PSS-10 ranges from 0 to 40, with higher
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18 scores indicating greater perceived stress and scores of 10 or more indicating moderate
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20 to high perceived stress [44]. The Chinese version of PSS-10 used in the present study
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22 showed satisfactory internal consistency, with a Cronbach's α of 0.79.
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30 **Perceived Devaluation and Discrimination Scale (PDD)**

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32 The 12-item Perceived Devaluation and Discrimination Scale (PDD), originated
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34 from the Link disease stigma scale series, is a widely used scale for measuring
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36 perceived stigma [45-47]. The PDD includes two factors: devaluation (5 items) and
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38 discrimination (7items). Each item is scored on a Likert-type scale of 5, ranging from
39
40 1 (fully agree) to 5 (totally disagree). Items 1, 2, 3, 4, 8 and 10 were reverse-coded. The
41
42 total score ranges from 12 to 60, with higher score indicating higher level of perceived
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44 stigma [48]. The PDD showed good reliability with a Cronbach’s alpha of 0.78 in the
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46 original study[45]. The Chinese version of PDD also showed good reliability in other
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48 studies[49]. In the current study, the PDD showed acceptable internal consistency with
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50 a Cronbach's alpha of 0.70.
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58 **Patient health questionnaire (PHQ-9)**

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4 The 9-item Patient Health Questionnaire (PHQ-9) is one of the most widely used
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6 screening tools for assessing depressive symptoms over the previous two weeks [50].
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8 Each item is scored on a Likert-type scale of 4, ranging from 0 (not at all) to 3 (nearly
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10 every day). The total score ranges from 0 to 27, with higher score indicating more
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12 severe depressive symptoms and a cutoff value of 10 distinguishing depression from its
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14 absence. The PHQ-9 was first translated into Chinese by Yeung et al. in 2008, and
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16 showed good reliability and validity in the Chinese population [51]. The Chinese
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18 version of PHQ-9 shows good internal consistency in the current study, with a
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20 Cronbach's Coefficient of 0.93.
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27 **Generalized anxiety disorder scale (GAD-7)**

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30 The 7-item Generalized Anxiety Disorder scale (GAD-7) is one of the most widely
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32 used screening tools for assessing anxiety symptoms during the previous two weeks
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34 [52]. Each item is scored on a Likert-type scale of 4, ranging from 0 (not at all) to 3
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36 (nearly every day). The total score ranges from 0 to 21, with higher score indicating
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38 more severe anxiety symptoms and a cutoff value of 10 distinguishing anxiety and non-
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40 anxiety [53]. The GAD-7 was first translated into Chinese by He X et
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42 al. [54], and showed good reliability and validity in the Chinese population [55]. The
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44 Chinese version of GAD-7 showed good internal consistency in the current study, with
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46 a Cronbach's Coefficient of 0.95.
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53 **Multidimensional scale of perceived social support (MSPSS)**

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56 The 12-item perceived social support multidimensional scale (MSPSS) is a widely
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58 used scale to measure the strength of support respondents received from three different
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4 sources: family, friends and significant others [56]. Each item is scored on a Likert-
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6 type scale of 7, ranging from 1 (very strongly disagree) to 7 (very strongly agree). The
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8 total score ranges from 12 to 84, with higher score indicating higher social support [56,
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10 57]. The MSPSS was first translated into Chinese by Huang L et al in 1996[58]. It
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12 showed good reliability with a Cronbach's alpha of 0.85-0.91 in the original study [57].
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14 The Chinese version of MSPSS in the current study showed good internal consistency
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16 with a Cronbach's Coefficient of 0.95.
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22 **Family adaptation, partnership, growth, affection and resolve index scale** 23 24 **(APGAR)** 25

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27 The 5-item Family adaptation, partnership, growth, affection and resolve index scale
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29 (APGAR) is a widely used scale to measure one's satisfaction with their family
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31 functionality. Each item is scored on a Likert-type scale of 3, ranging from 0 (almost
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33 never) to 2 (almost always) [59]. The total score ranges from 0 to 10, with higher score
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35 indicating higher satisfaction with family functioning. The APGAR has been widely
36
37 used and well validated in many previous studies, with Cronbach α of 0.86 in the initial
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39 rating [60-62]. The Chinese version of APGAR in the current study showed good
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41 internal consistency with a Cronbach's Coefficient of 0.95.
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48 **Caregiving rewarding feelings (CRF)** 49

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51 The 12-item caregiving rewarding feelings (CRF) measures positive emotions of
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53 caregivers during care of a family member with schizophrenia. CRF was initially
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55 developed based on qualitative interviews with 30 primary caregivers of people with
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57 schizophrenia, then validated in a larger sample. The development and validation of the
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4 CRF have been described elsewhere [63]. Some sample items include whether caring
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6 for a family member with schizophrenia makes them become "more loving and patient"
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8 "gain a lot of respect " "more active and optimistic, " "more responsible". Each item is
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10 scored on a Likert-type scale of 5, ranging from 1 "totally disagree" to 5 "strongly
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12 agree". The total score ranges from 0 to 36, with higher score indicating more positive
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14 feelings. The CRF in the current study showed good reliability with a Cronbach's alpha
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16 of 0.96.
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25 **Statistical analyses**

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27 Amos 22.0 (SPSS Inc., Chicago, IL, USA) and IBM SPSS statistics 23 (IBM,
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29 Armonk, New York, America) were used for statistical analyses. The
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31 sociodemographic characteristics of the samples were examined using descriptive
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33 statistics, including mean and standard deviation (SD) for continuous variables,
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35 frequency and percentage for categorical variables.
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41 Internal consistency reliability was assessed using Cronbach α for the total scale of
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43 PSS-10 and its two subscales. A Cronbach α level of ≥ 0.70 indicates good reliability
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45 [64]. Test-retest reliability was calculated in a subsample of these participants (n =25)
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47 who were randomly assessed again 2 weeks later to allow calculation of the intraclass
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49 correlation coefficient (ICC). An ICC value of ≥ 0.75 indicates good test-retest
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51 reliability[65, 66].
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56 Factor structure was evaluated by Confirmatory factor analysis (CFA) to test the a
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58 priori two-factor structure for the PSS-10. Kline (2005) and Byrne (2001) suggested
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4 the following CFA goodness-of-fit measures for model fit evaluation: goodness-of-fit
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6 index (GFI) >0.9, adjust goodness-of-fit index(AGFI)>0.9, comparing fit index
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8 (CFI)>0.9, non-normal fit index (NNFI)>0.90, standard root mean square residual
9
10 (SRMR)<0.08, root mean square error of approximate (RMSEA)<0.08, Tucker-Lewis
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12 Index (TLI)>0.9 [67-69].
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17 Concurrent validity was assessed using Pearson product–moment correlations with
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19 an expected significant positive correlation with the PDD, PHQ-9, and GAD-7; and
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21 expected significant negative correlations with the MSPSS, APGAR, and CRF.
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27 **Results**

28 **Sample demographics**

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30 Table 1 shows the socio-demographic characteristics of the sample. The caregivers
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32 had a mean (SD) age of 60.90 (12.28) years. Most caregivers were spouses or parents
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34 (80.18%), not employed (85.6%), of middle and high school education (61.5%), and
35
36 married/cohabited (75.7%). Over half were female (54.1%), and had an annual income
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38 of lower than 20,000 RMB (56.6%).
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45 **Reliability**

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47 Internal consistency reliability, as measured by Cronbach's alpha coefficient, was
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49 0.79 for the total score of the PSS-10, 0.88 for the subscale of perceived helplessness,
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51 and 0.79 for the subscale of perceived self-efficacy. These results indicate good internal
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53 consistency reliability. The ICC for the total score was 0.91 ($p < 0.001$), exceeding the
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55 recommended standard of 0.70 and indicating good test-retest reliability.
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Factor structure

Confirmatory factor analysis (CFA) was used to test the a priori two-factor structure of PSS-10. The two-factor structure was supported by the following goodness-of-fit statistics:

$\chi^2 / df = 2.628 < 3$, $p < 0.001$; GFI=0.963; AGFI=0.937; CFI=0.972; NNFI=0.961; TLI=0.961; RMSEA=0.061; SRMR=0.061. All these indexes indicated good or acceptable model fit. Figure 1 shows visualization of the two-factor model. Table 2 displays the means, standard deviations, and factor loadings of all 10 items. All items loaded well in their respective domains, with factoring loading ranging from 0.61-0.83 for subscale of perceived helplessness, and 0.60-0.83 for the subscale of perceived self-efficacy. The correlation between the two scales of PSS-10 was 0.006 ($p < 0.001$).

Concurrent validity

The concurrent validity of PSS-10 was verified using correlational analysis. As shown in Table 3, the total score of the PSS-10 and its two subscales were positively correlated with PDD ($r: 0.07$ to 0.16), PHQ-9 ($r: 0.17$ to 0.54), and GAD-7 ($r: 0.14$ to 0.62). The scores of PSS-10 and its two subscales were significantly negatively correlated with MSPSS-12 ($r: -0.24$ to -0.13), APGAR-5 ($r: -0.35$ to -0.19), and CRF-12 ($r: -0.45$ to -0.33). All the correlation coefficients were significant at $p = 0.01$, which confirmed the concurrent validity of PSS-10.

Discussion

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4 PSS-10 is one of the most widely used scales for stress assessment and has been
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6 translated into more than 20 languages [20]. This study validated the Chinese version
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8 of PSS-10 among family caregivers of persons with schizophrenia. Overall, the PSS-
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10 10 showed good internal consistency and test–retest reliability, and confirmatory factor
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12 analysis supported the a priori two-factor structure with favorable model fit indices.
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14 Concurrent validity was also supported by significant positive correlations with stigma,
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16 depression, and anxiety, and significant negative relationships with social support,
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18 family functioning, and caregiving rewarding feelings. Thus, the PSS-10 demonstrated
19
20 psychometrically sound properties for assessing the subjective experience of stress
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22 among caregivers of people with schizophrenia.
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30 The Cronbach α value for the total scale and two subscales of PSS-10 exceeded the
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32 recommended 0.70, indicating high internal consistency reliability. This finding is
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34 consistent with previous studies of Chinese [33-35] and non-Chinese samples, such as
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36 Japan [70], South Korea [71], the United States [72], and Sweden [21]. High test–retest
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38 reliability was supported by high ICC of the total score, also showing the stability of
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40 PSS-10 in assessing perceived stress over time. However, test–retest reliability findings
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42 must be interpreted with caution because of the relatively small sample size. Future
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44 research may benefit from using a larger sample size to examine test–retest reliability.
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50 Confirmatory factor analysis validated the a priori two-factor structure of PSS-10:
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52 perceived helplessness and perceived self-efficacy. Perceived helplessness includes 6
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54 negative phrasing items (item 1,2,3,6,9,10) that reflect a lack of control and negative
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56 emotions, while perceived self-efficacy includes 4 positive phrasing items (item 4,5,7,
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4 8) that reflect confidence in dealing with things and positive emotions. The favorable
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6 model fit indices show the two-factor structure is good and the fit acceptable. Also, in
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9 line with our theoretical hypothesis, all items of PSS-10 had high factor loadings on its
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11 specified factors, further showing the robustness of two-factor structure of the PSS-10.
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14 The two-factor structure found in the current sample is consistent with previous
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16 research on the use of PSS-10 in other populations, such as university students [34, 52,
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18 73], general adult samples [33, 35, 74-76], and clinical patients [36, 40]. What is
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20 noteworthy is that there has been wide debate about whether PSS-10 should be used as
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22 a full scale [19, 30, 33], or two separate subscales. Some researchers believe that the
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24 two subscales measure different components of the stress experience [76] and have
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26 suggested using them separately [77]. In the current study, the low correlation
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28 coefficient of 0.09 between the two subscales implies that the two factors may be
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30 unrelated and reflect different domains of perceived stress, which is consistent with the
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32 original developer-Cohen's conceptualization of the scale (1988). It seems that the PSS-
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34 10 can be used either as a whole scale or as two subscales depending on the research
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36 questions under study.
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47 The concurrent validity of PSS-10 was demonstrated by its significant positive
48
49 correlations with PDD, PHQ-9, and GAD-7, as well as significant negative correlations
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51 with MSPSS12, APGAR, and CRF. This finding is consistent with previous studies
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53 showing a negative health outcomes related to high perceived stress among caregivers
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55 of people with schizophrenia, such as increased depression and anxiety, decreased
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4 family functioning and rewarding feelings, which may be related to their increased
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6 feelings of stigma and reduced social support [10, 12, 25] Understanding the
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8 relationship between perceived stress and health outcomes of family caregivers may
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10 guide further family caregiver interventions.
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15 The present study also had several limitations. First, the sample were recruited from
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17 12 urban communities of Changsha city and thus may not representative of other areas,
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19 especially rural communities. Future multi-center studies may address this issue.
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21 Second, the cross-sectional design of the study may preclude testing of sensitivity to
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23 change for the PSS-10; subsequent longitudinal research should examine this. Third,
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25 test-retest reliability was based on a relatively small sample size, which may be further
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27 confirmed in a larger sample.
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38 **Conclusion**

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42 In summary, the PSS-10 has good psychometric characteristics assessing the
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44 perceived stress of family caregivers of people living with schizophrenia, including
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46 good internal consistency, test-retest reliability, and concurrent validity. Confirmatory
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48 factor analysis confirmed the a priori two-factor structure: perceived helplessness and
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50 perceived self-efficacy in the current population. Our findings provide reliable evidence
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52 for the use of PSS-10 in future studies to assess perceived stress among caregivers of
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54 people living with schizophrenia, and potentially, other caregiving samples.
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Acknowledgements

This work was funded by a grant from the National Natural Science Foundation of China (Grant Number 71804197) and the China Scholarship Council (CSC). The authors would like to thank all the families of the persons with schizophrenia for their participation in the WIFI program and for openly sharing their feelings and experiences. We also thank the Changsha Psychiatric Hospital as well as the 12 community health centers for their collaboration and support.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions:

All authors have made substantial contributions to the study conception and design, data collection and analysis, as well as to the development and editing of the manuscript. XT, SJX and YY contributed to the conception and design of the study, XT, SJX, FZ, DW, XL and YY contributed to the research conduction and data collection, XT, SJX and FZ contributed to data analyses, DW, XL, XT, SJX and YY contributed to data interpretation. XT and SJX drafted the article while XT, XSJ, FZ, DW, XL and YY critically appraised it and revised it. All authors approved the final version of manuscript for submission and publication and agreed to be accountable for all aspects

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4 of the work.
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9 **Ethics approval and consent to participate**

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11 The Institutional review board of Xiangya School of Public Health Central South
12 University (No.: XYGW-2019-029) has approved and regulates the ethical execution
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17 of this research.
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22 **Availability of Data and Materials**

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24 The datasets used and/or analyzed during the current study are available from the
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26
27 corresponding author on reasonable request.
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32 **Consent for publication**

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35 Not applicable.
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For peer review only

Table 1. Demographic characteristics of the participants (N = 449)

Characteristics		M (sd)/N (%)
		N=449
Age(years)	18-59	169 (37.6)
	60-100	280 (62.4)
	Mean (SD)	60.90 (12.28)
Gender	Male	206 (45.9)
	Female	243 (54.1)
Occupation	Employed	65 (14.4)
	Not employed	384 (85.6)
Education	Primary and below	130 (29.0)
	Middle and high	276 (61.5)
	College and above	43 (9.5)
Marital status	Single	19 (4.2)
	Married/cohabited	340 (75.7)
	Else(divorced/separated/widowed)	90 (20.0)
Kinship	Parents	254 (56.57)
	Spouse	106 (23.61)
	Children	29 (6.46)
	Siblings	49 (10.91)
	Other	11 (2.45)
Income (RMB/year)	20000 or less	254 (56.6)
	20001-40000	99 (22.0)
	40000 or greater	96 (21.4)

Table 2. Descriptive statistics and factor loadings of the PSS-10 (N=439)

Items	Mean (SD)	Factor loading
Factor 1: Crisis perception ($\alpha = 0.88$)		
1. Been upset	1.75 (1.09)	0.78
2. Unable to control	1.80 (1.20)	0.83
3. Nervous and stressed	2.02 (1.15)	0.81
6. Could not cope	1.78 (1.09)	0.71
9. Been angered	1.74 (1.24)	0.61
10. Could not overcome	1.80 (1.20)	0.69
Factor 2: Coping ability perception ($\alpha = 0.79$)		
4. Felt confident	1.68 (1.23)	0.60
5. Going your way	2.30 (1.17)	0.62
7. Control irritations	1.74 (1.11)	0.75
8. On top of things	1.91 (1.18)	0.83

Table 3 Correlations of PSS-10 and its two subscales with other variables

Variables	1	2	3	4	5	6	7	8	9
1. PSS-10	1.00								
2. Perceived helplessness-sub	0.88**	1.00							
3. Perceived self-efficacy-sub	0.51**	0.09	1.00						
4.PDD	0.16**	0.14**	0.07	1.00					
5. PHQ-9	0.54**	0.54**	0.17**	-0.02	1.00				
6. GAD-7	0.62**	0.65**	0.14**	0.01	0.72**	1.00			
7.MSPSS-12	-0.22**	-0.13**	-0.24**	-0.31**	-0.11*	-0.09	1.00		
8.APGAR-5	-0.30**	-0.19**	-0.35**	-0.27**	-0.18**	-0.17**	0.56**	1.00	
9.CRF-12	-0.33**	-0.15**	-0.45**	-0.27**	-0.12**	-0.08	0.54**	0.66**	1.00

& Spearman correlation using pairwise deletion for missing values

*P< 0.05, ** P<0.01

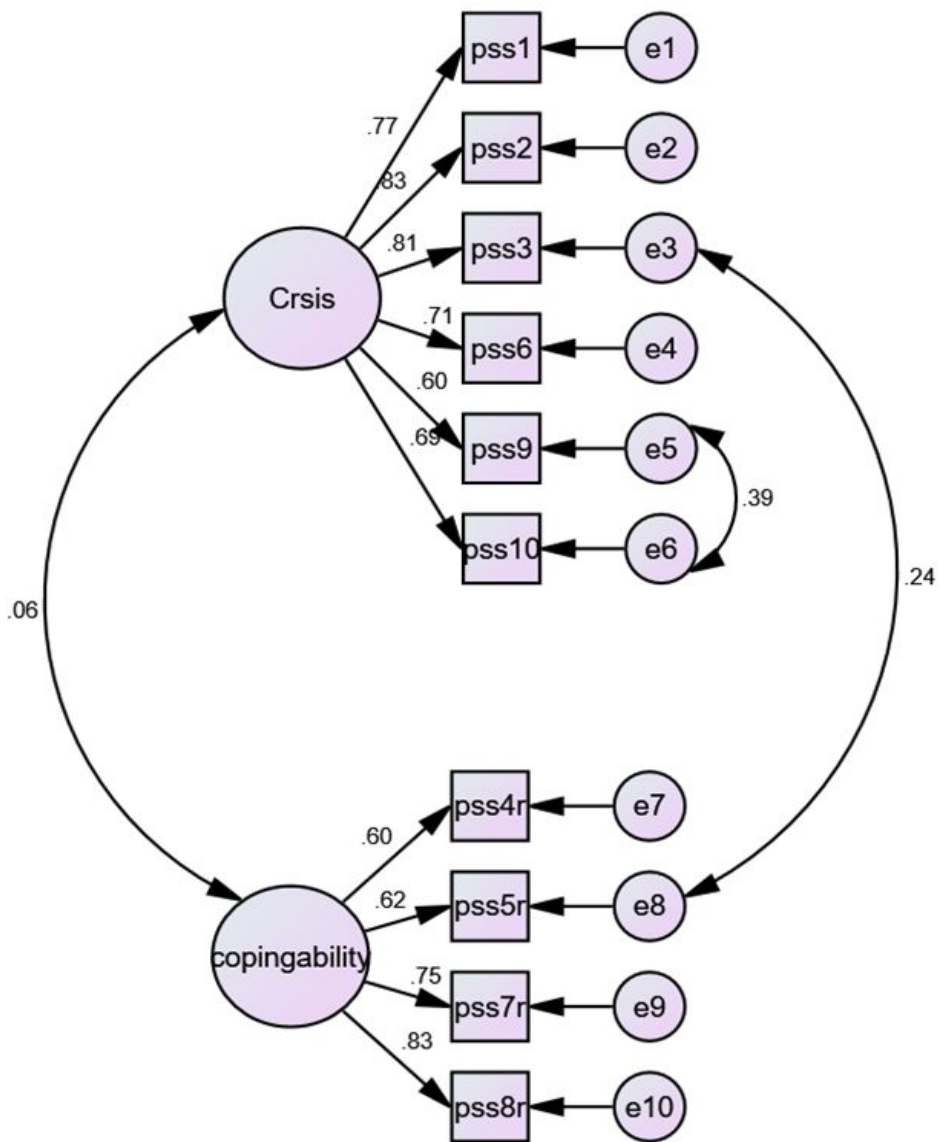


FIGURE 1 | Standardized factor loadings for the two-factor model of the Perceived Stress Scale (PSS-10) (N=439)

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1-3
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3-5
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6-8
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8-9
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	8-9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	9-13
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	8-9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	13
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	13-14
		(b) Describe any methods used to examine subgroups and interactions	13-14
	(c) Explain how missing data were addressed	NA	
	(d) If applicable, describe analytical methods taking account of sampling strategy	NA	
	(e) Describe any sensitivity analyses	13-14	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	14
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	14
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	14-15

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Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	NA
		(b) Report category boundaries when continuous variables were categorized	14-15
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	14-15
Discussion			
Key results	18	Summarise key results with reference to study objectives	18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	16-18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Psychometric validation of the Perceived Stress Scale (PSS-10) among family caregivers of people with schizophrenia in China

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2023-076372.R1
Article Type:	Original research
Date Submitted by the Author:	18-Oct-2023
Complete List of Authors:	Tao, Xiao ; Central South University Third Xiangya Hospital Zhu, Feng ; Central South University Xiangya School of Public Health Wang, Dan ; Central South University Xiangya School of Public Health Liu, Xiang ; Central South University Xiangya School of Public Health Xi, Shi-jun; Central South University Xiangya School of Public Health, Department of Social Medicine and Health Management; Foshan Center for Disease Control and Prevention YU, YU; Xiangya Hospital Central South University, ; Yale University School of Medicine, Division of Prevention and Community Research
Primary Subject Heading:	Mental health
Secondary Subject Heading:	Mental health, Nursing, Public health
Keywords:	Psychometrics, PSYCHIATRY, Schizophrenia & psychotic disorders < PSYCHIATRY, Nursing Care

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Title Page

Title: Psychometric validation of the Perceived Stress Scale (PSS-10) among family caregivers of people with schizophrenia in China

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For peer review only

Abstract

Background: The 10-item Perceived Stress Scale (PSS-10) is a widely used measure of perceived stress that has been validated in various populations, yet with inconsistent results on its factor structure. The present study examines the reliability and validity of the PSS-10 in a population not previously examined: Chinese family caregivers of persons with schizophrenia, with a focus on factor analysis.

Methods: A sample of 449 family caregivers of persons with schizophrenia were recruited for psychometric testing of the scale. The factor structure of PSS-10 was tested by randomly dividing the sample into two groups for both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). The scale was further tested for internal consistency, test-retest reliability, convergent validity, discriminant validity, and concurrent validity.

Results: EFA extracted two factors: perceived helplessness with 6 negative phrasing items and perceived efficacy with 4 positive phrasing items. CFA confirmed the structure of two factors with satisfactory model fit indices. Convergent validity was supported by high standard regression weight (SRW=0.78-0.92), average variance extracted (AVE=0.79-0.81), and composite reliability (CR=0.88-0.94), while discriminant validity was confirmed by higher AVE estimates than the squared inter-construct correlations. The PSS-10 showed good internal consistency and test-retest reliability, with Cronbach's alpha of 0.79 and ICC of 0.91, respectively. Concurrent validity was demonstrated by its significant positive correlations with stigma, depression, and anxiety, as well as significant negative correlations with social support,

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4 family functioning, and positive caregiving experiences.
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6 **Conclusion:** The two-factor PSS-10 has good psychometric characteristics assessing
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8 the perceived stress of family caregivers of people with schizophrenia. The findings
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10 indicate that the PSS-10 can be used to measure perceived stress in future research and
11
12 practice among caregivers of people with schizophrenia, and potentially, other
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14 caregiving samples.
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22 **Keywords:** 10-item Perceived Stress Scale (PSS-10), psychometric testing,
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24 reliability, validity, exploratory factor analysis (EFA), confirmatory factor analysis
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26 (CFA)
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32 **Strengths and limitations of this study**

- 35 1. The first study to validate the most widely used 10-item Perceived Stress Scale
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37 (PSS-10) among a most stressed yet understudied population--- family
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39 caregivers of people with schizophrenia.
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- 42 2. The factor structure of PSS-10 was tested by randomly dividing the sample
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44 into two groups for both exploratory factor analysis (EFA) and confirmatory
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46 factor analysis (CFA).
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- 49 3. An exhaustive testing of multiple psychometric properties of the PSS-10
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51 including EFA, CFA, internal consistency, test-retest reliability, convergent
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53 validity, discriminant validity, and concurrent validity.
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- 56 4. The cross-sectional design of the study may preclude testing of sensitivity to
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change for the PSS-10.

Psychometric validation of the Perceived Stress Scale (PSS-10) among family caregivers of people with schizophrenia in China

Introduction

Schizophrenia is a severe, debilitating chronic psychiatric disorder that causes impairments in cognition, speech, thinking, and emotional responsiveness [1]. It impairs individuals' social and occupational functioning, as well as limits their ability to carry out daily activities [2]. For instance, Wiersma et al. (2000) conducted a 15-year multicenter survey in Europe and found that social dysfunction was widespread and persistent in schizophrenia [3]. Similar findings were also reported in China [4]. Consequently, people with schizophrenia often require ongoing support and care, which in many Asian countries, is often provided by family members [5]. In China, efforts have been made to establish community-based rehabilitation services for people with schizophrenia but with family members assuming the major role of caregiving [6]. These family caregivers represent a large and invisible group to substitute for the under-resourced mental health service system to provide high-quality care to people with schizophrenia[7]. Caring for people with schizophrenia can be a demanding activity that challenges the physical and mental health of family caregivers [8]. As a result, family caregivers may report a high level of stress, which can lead to negative health outcomes and reduced quality of life [9].

Studies have shown that the stress experienced by family caregivers of people with

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4 schizophrenia is higher than for caregivers of people with other prolonged illnesses,
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6 which is related to higher psychological distress, depression, and anxiety [10, 11].
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9 Caregivers' stress may also result in conflict among family members and increased
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11 family dysfunction [8, 12]. These caregivers also report increased perceived stigma due
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13 to their loved one's mental illness [13-15] as well as insufficient social support [13].
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16 For example, family caregivers may report shame due to disruptive public behaviors of
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18 the family member with schizophrenia and seek to hide them from the public as much
19
20 as possible [16, 17]. This can result in social isolation, lack of social support, and social
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22 exclusion, which may further aggravate their stress [16, 17]. Thus, it is both important
23
24 and meaningful to assess their stress levels using reliable and valid scales, which not
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26 only helps strengthen our understanding of their mental well-being for further
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28 intervention and support but also can guide the assessment of future intervention effects.
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35 The perceived stress scale (PSS) is one of the most widely used measures for
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37 assessing perceived stress in the world [18, 19]. The PSS measures the degree to which
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39 participants perceive unpredictability, lack of control, or overload in their life. The
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41 original PSS included 14 items (PSS-14), which were further abbreviated into two short
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43 versions: PSS-10 and PSS-4 [18, 20]. Although the original PSS-14 showed sufficient
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45 validity and reliability, the shorter version (PSS-10) has superior psychometric
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47 properties and is recommended for research [21]. The PSS-10 has been translated into
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49 various languages and validated in various countries, such as Sweden [22], France [23],
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51 Korea [24], Mexico [25], the United States [26], Arabia [27], Serbia [28], Germany [29],
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53 Viet Nam [30], Brazil [31] and Thailand [32]. The PSS-10 was first translated into
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4 Simplified Chinese (the language of the Chinese mainland) by Yang and Huang in 2003
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6 [33], and approved by its original developer Dr. Cohen [34]. The Simplified Chinese
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8 version of the PSS-10 (C-PSS-10) has been used with various populations including
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10 university students [35], elderly service workers [36], and cardiac patients [37], but its
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12 psychometric properties among family caregivers of individuals with prolonged
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14 illnesses, such as with schizophrenia, has not been examined in Chinese communities.
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16 In addition, although there are abundant psychometric testing studies on PSS-10,
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18 inconsistencies exist in the results of its factor structure. Although the original
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20 developer considered it as a uni-dimensional measure[18, 20], dozens of subsequent
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22 studies have proposed a two-factor structure[38-40], and there are also a few studies
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24 showing a three-factor structure[41, 42].
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32 Given the lack of validation of PSS-10 among family caregivers of people with
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34 schizophrenia and the conflicting evidence on its factor structure, we conducted the
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36 current study to run a comprehensive psychometric testing on the PSS-10 among a
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38 Chinese community sample of family caregivers of people with schizophrenia.
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40 Specifically, we tested the factor structure of PSS-10 by randomly dividing the sample
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42 into two groups for exploratory factor analysis (EFA) and confirmatory factor analysis
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44 (CFA), respectively. In addition, we examined other psychometric properties of PSS-
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46 10 including internal consistency reliability, test-retest reliability, convergent validity,
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48 discriminant validity, and concurrent validity.
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58 **Materials and methods**

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Participants and procedure

This cross-sectional study used baseline data from a large community sample who agreed to participate in an intervention to support family caregivers of people with schizophrenia [43]. A total of 449 family caregivers of people with schizophrenia were recruited from 12 communities affiliated with the Changsha Psychiatric Hospital through the "686 program". "686 program" is China's largest demonstration project aimed at integrating hospital and community services for serious mental illness [44]. The Changsha Psychiatric Hospital has provided mental health services to the 12 communities, including free antipsychotic medicine delivery. Every month, a medical team from the Changsha Psychiatric Hospital went to each community health center to distribute free medicine and run routine health check-ups for registered clients with serious mental illnesses. Inclusion criteria of family caregivers were: 1) caring for a family member registered in the "686 program" and satisfied the Chinese classification of Mental Disorders (CCMD-3) or the international classification of Schizophrenia (ICD-10) criteria for schizophrenia; 2) living with the care recipient for at least the last two years; 3) aged ≥ 18 years; 4) able to read and communicate and complete the questionnaire. Exclusion criteria included: 1) care recipient not registered in the 686 program; 2) care recipient diagnosed with a mental illness other than schizophrenia, such as depression and epilepsy; 3) care recipient living alone; 4) family caregiver having a serious physical or mental illness and thus were unable to communicate and complete the interview; 5) family caregiver younger than 18 years. Our final sample size was 449 participants, satisfying the sample size requirement of at least 10

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4 participants for each item in psychometric testing of scales [45].
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6 Data collection was conducted from May 2019 and September 2019. Family
7 caregivers were approached during the free medicine delivery process by the medical
8 team and invited to participate in the study. The medical team explained in detail about
9 the study and referred interested caregivers to our research team. The research team
10 fully explained the research to each family caregiver and fully informed the benefits
11 and risks of participation, as well as their right to withdraw at any time. After providing
12 written informed consent, the caregivers received face-to-face interviews conducted by
13 our research team and completed a battery of questionnaires. The entire interview took
14 approximately 20-40 minutes, and each participant was reimbursed RMB 20 yuan
15 (USD 2.80) for the completion of the questionnaire.
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32 **Patient and Public Involvement Statement**

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35 None
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37 **Instruments**

38 **Perceived stress scale (PSS-10)**

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41 The 10-item perceived stress scale (PSS-10) is a self-assessed measure of
42 psychological stress experienced over the past 30 days[18, 20]. The scale includes 6
43 negative items (item 1,2,3,6,9,10) assessing the degree of lack of control and negative
44 reactions (also named as negative stress, perceived helplessness, or perceived stress),
45 as well as 4 positive items (item 4,5,7,8) assessing one's ability to cope with existing
46 stressors (also named as positive stress, perceived efficacy, or perceived control) [37,
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59 46]. Each answer is scored on a 5-point Likert scale ranging from 0 (never) to 4 (very
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4 often) and the 4 positive items are reverse-coded so that higher scores indicate higher
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6 stress. The total score of PSS-10 ranges from 0 to 40, with higher scores indicating
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8 greater perceived stress and scores of 10 or more indicating moderate to high perceived
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10 stress [47]. The Chinese version of PSS-10 used in the present study showed
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12 satisfactory internal consistency, with a Cronbach's α of 0.79.
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16 17 **Perceived Devaluation and Discrimination Scale (PDD)**

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19 The 12-item Perceived Devaluation and Discrimination Scale (PDD), originated
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21 from the Link disease stigma scale series, is a widely used scale for measuring
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23 perceived stigma [48-50]. The PDD includes two factors: devaluation (5 items) and
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25 discrimination (7 items). Each item is scored on a 5-point Likert scale ranging from 1
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27 (fully agree) to 5 (totally disagree). Items 1, 2, 3, 4, 8, and 10 are reverse-coded. The
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29 total score ranges from 12 to 60, with higher scores indicating higher levels of perceived
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31 stigma [51]. The PDD showed good reliability with a Cronbach's alpha of 0.78 in the
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33 original study[48]. The Chinese version of PDD also showed good reliability in other
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35 studies[52]. In the current study, the PDD showed acceptable internal consistency with
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37 a Cronbach's alpha of 0.70.
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45 46 **Patient health questionnaire (PHQ-9)**

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48 The 9-item Patient Health Questionnaire (PHQ-9) is one of the most widely used
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50 screening tools for assessing depressive symptoms over the previous two weeks [53].
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52 Each item is scored on a 4-point Likert scale ranging from 0 (not at all) to 3 (nearly
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54 every day). The total score ranges from 0 to 27, with higher scores indicating more
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56 severe depressive symptoms and a cutoff value of 10 distinguishing between depression
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4 and non-depression. The PHQ-9 was first translated into Chinese by Yeung et al. in
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6 2008 and showed good reliability and validity in the Chinese population [54]. The
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8 Chinese version of PHQ-9 shows good internal consistency in the current study, with a
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10 Cronbach's Coefficient of 0.93.
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13 14 **Generalized anxiety disorder scale (GAD-7)**

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17 The 7-item Generalized Anxiety Disorder scale (GAD-7) is one of the most widely
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19 used screening tools for assessing anxiety symptoms during the previous two weeks
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21 [55]. Each item is scored on a 4-point Likert scale ranging from 0 (not at all) to 3 (nearly
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23 every day). The total score ranges from 0 to 21, with higher scores indicating more
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25 severe anxiety symptoms and a cutoff value of 10 distinguishing between anxiety and
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27 non-anxiety [56]. The GAD-7 was first translated into translated it into Chinese by He
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29 X et Al. [57], and showed good reliability and validity in the Chinese population[58].
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31 The Chinese version of GAD-7 showed good internal consistency in the current study,
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33 with a Cronbach's Coefficient of 0.95.
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40 **Multidimensional scale of perceived social support (MSPSS)**

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43 The 12-item perceived social support multidimensional scale (MSPSS) is a widely
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45 used scale to measure the strength of support respondents received from three different
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47 sources: family, friends, and significant others [59]. Each item is scored on a 7-point
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49 Likert scale ranging from 1 (very strongly disagree) to 7 (very strongly agree). The total
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51 score ranges from 12 to 84, with higher scores indicating higher social support [59, 60].
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53 The MSPSS was first translated into Chinese by Huang L et al in 1996[61]. It showed
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55 good reliability with a Cronbach's alpha of 0.85-0.91 in the original study [60]. The
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4 Chinese version of MSPSS in the current study showed good internal consistency with
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6 a Cronbach's Coefficient of 0.95.
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9 **Family adaptation, partnership, growth, affection, and resolve index scale**
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11 **(APGAR)**
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14 The 5-item Family adaptation, partnership, growth, affection, and resolve index scale
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16 (APGAR) is a widely used scale to measure one's satisfaction with their family
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18 functionality. Each item is scored on a 3-point Likert scale ranging from 0 (almost never)
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20 to 2 (almost always) [62]. The total score ranges from 0 to 10, with a higher score
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22 indicating higher satisfaction with family functioning. The APGAR has been widely
23
24 used and well-validated in many previous studies, with Cronbach α of 0.86 in the initial
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26 rating [63-65]. The Chinese version of APGAR in the current study showed good
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28 internal consistency with a Cronbach's Coefficient of 0.95.
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35 **Caregiving rewarding feelings (CRF)**
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38 The 12-item caregiving rewarding feelings (CRF) measures the positive emotions of
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40 caregivers during the care of a family member with schizophrenia. CRF was initially
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42 developed based on qualitative interviews with 30 primary caregivers of people with
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44 schizophrenia, then validated in a larger sample. The development and validation of the
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46 CRF have been described elsewhere [66, 67]. Some sample items include whether
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48 caring for a family member with schizophrenia makes them become "more loving and
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50 patient" "gain a lot of respect " "more active and optimistic, " "more responsible". Each
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52 item is scored on a 4-point Likert scale ranging from 0 "never" to 3 "nearly always".
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4 The total score ranges from 0 to 36, with higher scores indicating more positive feelings.
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6 The CRF in the current study showed good reliability with a Cronbach's alpha of 0.96.
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10 11 **Statistical analyses** 12

13
14 Amos 22.0 (SPSS Inc., Chicago, IL, USA) and IBM SPSS statistics 23 (IBM,
15 Armonk, New York, America) were used for statistical analyses. The
16 sociodemographic characteristics of the samples were examined using descriptive
17 statistics, including mean and standard deviation (SD) for continuous variables, and
18 frequency and percentage for categorical variables.
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27 The factor structure of the PSS-10 was evaluated by both exploratory factor analysis
28 (EFA) and confirmatory factor analysis (CFA). The total sample was randomly and
29 equally divided into group 1 for EFA to build the model and group 2 for CFA to verify
30 the model. Kaiser–Meyer–Olkin (KMO) and Bartlett's test of sphericity were used to
31 test whether our data were suitable for factor analysis[68]. In EFA, principal component
32 factor analysis with oblique rotation was conducted to assess the underlying structure
33 of the PSS-10. Factors were extracted based on two criteria: (1) factors with eigenvalues
34 greater than 1, and (2) items with factor loadings greater than 0.40[68, 69].
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48 The theoretical model identified in EFA was further tested by CFA using the second
49 sample. Kline and Byrne suggested the following CFA goodness-of-fit measures for
50 model fit evaluation: goodness-of-fit index (GFI) >0.9, adjust goodness-of-fit
51 index(AGFI)>0.9, comparing fit index (CFI)>0.9, non-normal fit index (NNFI)>0.90,
52 standard root mean square residual (SRMR)<0.08, root mean square error of
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4 approximate (RMSEA) <0.08 , Tucker-Lewis Index (TLI) >0.9 [70-72]. Once a good fit
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6 was established, construct validity was further tested by calculating the following
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8 indicators: standard regression weight (SRW), average variance extracted (AVE), and
9
10 composite reliability (CR). According to Hair et al. [73], SRW ≥ 0.50 , AVE ≥ 0.50 , and
11
12 CR ≥ 0.70 indicate good convergent validity, while AVE for each construct greater than
13
14 CR ≥ 0.70 indicate good convergent validity, while AVE for each construct greater than
15
16 the squared inter-construct correlations indicates good discriminant validity.
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19 Internal consistency reliability was assessed using Cronbach α for the total scale of
20
21 PSS-10 and its subscales. A Cronbach α level of ≥ 0.70 indicates good reliability [74].
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23 Test-retest reliability was calculated in a subsample of these participants (n =25) who
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25 were randomly assessed again 2 weeks later to allow calculation of the intraclass
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27 correlation coefficient (ICC). An ICC value of ≥ 0.75 indicates good test-retest
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29 reliability[75, 76].
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35 Concurrent validity of the PSS-10 was assessed using Pearson product-moment
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37 correlations with expected significant positive correlations with perceived stigma (as
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39 measured by PDD), depression (as measured by PHQ-9), and anxiety (as measured by
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41 GAD-7); as well as expected significant negative correlations with social support (as
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43 measured by MSPSS), family functioning (as measured by APGAR), and positive
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45 caregiving experiences (as measured by CRF).
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51 52 53 **Results**

54 55 56 **Sample demographics**

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4 Table 1 shows the socio-demographic characteristics of the sample. The caregivers
5
6 had a mean (SD) age of 60.90 (12.28) years. Most caregivers were spouses or parents
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8 (80.18%), not employed (85.6%), of middle and high school education (61.5%), and
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10 married/cohabited (75.7%). Over half were female (54.1%) and had an annual income
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12 of lower than 20,000 RMB (56.6%).
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16 17 **Exploratory factor analysis**

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19 The underlying factor structure of the PSS-10 was first examined using EFA on the
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21 first half sample (N = 218). Kaiser–Meyer–Olkin test showed a KMO value of 0.93,
22
23 indicating good sampling adequacy. Bartlett’s test of sphericity ($\chi^2 = 1896.319$; $df = 45$,
24
25 $p < 0.001$) also suggested that inter-item correlations were large enough to perform
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27 EFA.
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32 Further EFA yielded a two-factor solution with two initial eigenvalues above 1
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34 (3.48/1.80) and all items with factor loadings >0.40 , which satisfied the predetermined
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36 factor extraction criteria (Table 2). The two-factor structure accounted for 89.5 % of
37
38 the total variance in the sample. The first factor was labeled as “perceived efficacy”,
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40 with an explained variance of 65.6%, and included all 6 negative items, with factor
41
42 loadings ranging from 0.70-0.82. The second factor was labeled as “perceived efficacy”,
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44 with an explained variance of 23.9%, and included all 4 negative items, with factor
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46 loadings ranging from 0.60-0.78. The inter-factor correlation was 0.60, suggesting
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48 overall high inter-correlations between the two factors.
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58 **Confirmatory factor analysis**

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4 The two-factor structure of PSS-10 identified in EFA was further tested using CFA
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6 on the second half sample (N=218). The two-factor structure was supported by the
7
8 following goodness-of-fit statistics: $\chi^2/df = 2.628 < 3$, $p < 0.001$; GFI=0.963;
9
10 AGFI=0.937; CFI=0.972; NNFI=0.961; TLI=0.961; RMSEA=0.061; SRMR=0.061.
11
12 All these indexes indicated a good or acceptable model fit. Figure 1 shows a
13
14 visualization of the two-factor model.
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19 Table 3 shows correlations between CFA factors, Composite Reliability (CR), and
20
21 Average Variance Extracted (AVE). The two subscales of the PSS-10 were all
22
23 significantly associated with the total PSS-10 scale as well as each other, with
24
25 correlation coefficients >0.50 , indicating a large effect size. The CFA demonstrated
26
27 good convergent validity of the PSS-10, with statistically significant SRW >0.50 (0.78-
28
29 0.92, Table 2), AVE >0.50 (0.79-0.81, Table 3), and composite reliability (CR) >0.70
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31 (0.88-0.94, Table 3). In addition, the CFA also confirmed good discriminant validity of
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33 the CRF, with each factor AVE estimate being higher than the squared inter-construct
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35 correlations with which it was associated (Table 3).
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43 **Reliability**

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45 Internal consistency reliability, as measured by Cronbach's alpha coefficient, was
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47 0.79 for the total score of the PSS-10, 0.88 for the subscale of perceived helplessness,
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49 and 0.79 for the subscale of perceived efficacy. These results indicate good internal
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51 consistency reliability. The ICC for the total score was 0.91 ($p < 0.001$), exceeding the
52
53 recommended standard of 0.75 and indicating good test-retest reliability.
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58 **Concurrent validity**

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4 The concurrent validity of PSS-10 was verified using correlational analysis. As
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6 shown in Table 4, the scores of PSS-10 and its two subscales were significantly
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8 positively correlated with PDD (r: 0.07 to 0.16), PHQ-9 (r: 0.17 to 0.54), and GAD-7
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10 (r: 0.14 to 0.62). The scores of PSS-10 and its two subscales were significantly
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12 negatively correlated with MSPSS-12 (r: - 0.24 to - 0.13), APGAR-5 (r: - 0.35 to -
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14 0.19), and CRF-12 (r: - 0.45 to - 0.33). All the correlation coefficients were significant
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16 at $p = 0.01$, which confirmed the concurrent validity of PSS-10.
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25 Discussion

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27 PSS-10 is one of the most widely used scales for stress assessment and has been
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29 translated into more than 20 languages [21]. However, PSS-10 has never been validated
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31 among family caregivers of people living with schizophrenia in China, an important yet
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33 understudied population that has been providing free and high-quality care to their
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35 loved ones with schizophrenia. In addition, factor analysis of the PSS-10 by previous
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37 studies has shown inconsistencies in its factor structures, with one, two, and three
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39 factors being proposed. This study tested the psychometric properties of the Chinese
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41 version of PSS-10 among family caregivers of people with schizophrenia, with a focus
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43 on factor analysis by randomly dividing the sample into two groups for EFA and CFA.
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50 Our results supported a two-factor structure of the PSS-10, with EFA yielding a two-
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52 factor structure, which was further verified by CFA with satisfactory model fit.
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54 Convergent validity was supported by high SRW, AVE, and construct reliability (CR),
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56 while discriminant validity was confirmed by higher AVE estimates than the squared
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4 inter-construct correlations. Overall, the PSS-10 showed good internal consistency with
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6 a high Cronbach α coefficient, and good test–retest reliability with a high ICC. The
7
8 concurrent validity of the pss-10 was also supported by its significant positive
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10 correlations with stigma, depression, and anxiety, and significant negative relationships
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12 with social support, family functioning, and caregiving rewarding feelings. Thus, the
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14 two-factor PSS-10 demonstrated psychometrically sound properties for assessing the
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16 subjective experience of stress among caregivers of people with schizophrenia.
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22 Our preliminary exploratory factor analysis showed a two-factor structure of PSS-
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24 10: perceived helplessness and perceived efficacy. Perceived helplessness includes 6
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26 negative phrasing items (items 1,2,3,6,9,10) that reflect a lack of control and negative
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28 emotions, while perceived efficacy includes 4 positive phrasing items (items 4,5,7, 8)
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30 that reflect confidence in dealing with things and positive emotions. Also, in line with
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32 our theoretical hypothesis, all items of PSS-10 had high factor loadings on their
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34 specified factors, further showing the robustness of the two-factor structure of the PSS-
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36 10. Subsequent confirmatory factor analysis also showed favorable model fit indices,
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38 further corroborating the two-factor structure of PSS-10. In addition, the CFA also
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40 demonstrated good convergent validity of the CRF, with statistically significant
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42 SRW >0.50 , AVE >0.50 , and construct reliability (CR) >0.70 , as well as good
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44 discriminant validity, with each factor AVE estimate being higher than the squared
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46 inter-construct correlations. Our findings were consistent with previous research
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48 showing a similar two-factor structure of PSS-10 in other populations, such as
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50 university students [35, 55, 77], general adult samples [34, 36, 78-80], and clinical
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4 patients [37, 81]. What is noteworthy is that there has been wide debate about whether
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6 PSS-10 should be used as a full scale [20, 31, 34], or two separate subscales. Some
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8 researchers believe that the two subscales measure different components of the stress
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10 experience [80] and have suggested using them separately [82]. In the current study,
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12 the high correlation coefficient of 0.60 between the two subscales implies that the two
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14 factors are highly correlated yet not redundant with each other. As a result, it is
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16 suggested the PSS-10 can be used as a whole scale or as two subscales depending on
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18 the research questions under study.
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26 The Cronbach α value for the total scale and two subscales of PSS-10 exceeded the
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28 recommended 0.70, indicating high internal consistency reliability. This finding is
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30 consistent with previous studies of Chinese [34-36] and non-Chinese samples, such as
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32 Japan [83], South Korea [84], the United States [85], and Sweden [22]. High test-retest
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34 reliability was supported by a high ICC of the total score, also showing the stability of
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36 PSS-10 in assessing perceived stress over time. However, test-retest reliability findings
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38 must be interpreted with caution because of the relatively small sample size. Future
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40 research may benefit from using a larger sample size to examine test-retest reliability.
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47 The concurrent validity of PSS-10 was demonstrated by its significant positive
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49 correlations with PDD, PHQ-9, and GAD-7, as well as significant negative correlations
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51 with MSPSS12, APGAR, and CRF. This finding is consistent with previous studies
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53 showing negative health outcomes related to high perceived stress among caregivers of
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55 people with schizophrenia, such as increased depression and anxiety, decreased family
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57 functioning and rewarding feelings, which may be related to their increased feelings of
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4 stigma and reduced social support [11, 13, 26] Understanding the relationship between
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6 perceived stress and health outcomes of family caregivers may guide further family
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8 caregiver interventions.
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13 The present study also had several limitations. First, the sample was recruited from
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15 12 urban communities of Changsha city and thus may not be representative of other
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17 areas, especially rural communities. Future multi-center studies may address this issue.
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19 Second, the cross-sectional design of the study may preclude testing of sensitivity to
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21 change for the PSS-10; subsequent longitudinal research should examine this. Third,
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23 test-retest reliability was based on a relatively small sample size, which may be further
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25 confirmed in a larger sample.
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31 32 **Conclusion**

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36 In summary, the PSS-10 has good psychometric characteristics assessing the
37
38 perceived stress of family caregivers of people living with schizophrenia, including
39
40 good internal consistency, test-retest reliability, convergent validity, discriminant
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42 validity, and concurrent validity. Both exploratory factor analysis and confirmatory
43
44 factor analysis supported a two-factor structure: perceived helplessness and perceived
45
46 efficacy in the current population. Our findings provide reliable evidence for the use of
47
48 PSS-10 in future studies to assess perceived stress among caregivers of people living
49
50 with schizophrenia, and potentially, other caregiving samples.
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58 **Acknowledgments**

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4 This work was funded by a grant from the National Natural Science Foundation of
5
6 China (Grant Number 71804197). The authors would like to thank all the families of
7
8 the persons with schizophrenia for their participation in the WIFI program and for
9
10 openly sharing their feelings and experiences. We also thank the Changsha Psychiatric
11
12 Hospital as well as the 12 community health centers for their collaboration and support.
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19 **Competing interests**

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21
22 The authors declare that they have no competing interests.
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27 **Authors' contributions:**

28
29 All authors have made substantial contributions to the study conception and design,
30
31 data collection and analysis, as well as to the development and editing of the manuscript.
32
33 XT, SJX, and YY contributed to the conception and design of the study, XT, SJX, FZ,
34
35 DW, XL, and YY contributed to the research conduction and data collection, XT, SJX,
36
37 and FZ contributed to data analyses, DW, XL, XT, SJX, and YY contributed to data
38
39 interpretation. XT and SJX drafted the article while XT, XSJ, FZ, DW, XL, and YY
40
41 critically appraised it and revised it. All authors approved the final version of the
42
43 manuscript for submission and publication and agreed to be accountable for all aspects
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45 of the work.
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56 **Ethics approval and consent to participate**

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58 The Institutional Review Board of Xiangya School of Public Health Central South
59
60

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3
4 University (No.: XYGW-2019-029) has approved and regulates the ethical execution
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6 of this research.
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10 11 **Availability of Data and Materials**

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14 The datasets used and/or analyzed during the current study are available from the
15
16 corresponding author upon reasonable request.
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20 21 22 **Consent for publication**

23
24 Not applicable.
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Table 1. Demographic characteristics of the participants (N = 449)

characteristics	M(sd)/N(%)	N=449
Age(years)	18-59	169(37.6)
	60-100	280(62.4)
	Mcan(SD)	60.90(12.28)
Gender	Male	206(45.9)
	Female	243(54.1)
Occupation	Employed	65(14.4)
	Not Employed	384(85.6)
Education	Primary and below	130(29.0)
	Middle and high	276(61.5)
	College and above	43(9.5)
Marital Status	Single	19(4.2)
	Married/cohabited	340(75.7)
	Else(divorced/separated/windowed)	90(20.0)
Kinship	Parents	254(56.57)
	Spouse	106(23.61)
	Children	29(6.46)
	Siblings	49(10.91)
	Other	11(2.45)
Income(RMB/year)	20000 or less	254(56.6)
	20001-40000	99(22.0)
	40000 or geater	96(21.4)

Table 2. Exploratory factor analysis of the PSS-10 (N=218)

Short item names	Mean (SD)	Components of the factors		Uniqueness	SRW
		Perceived helplessness	Perceived efficacy		
3. Nervous and stressed	2.02 (1.15)	0.82		0.22	0.83
2. Unable to control	1.80 (1.20)	0.78		0.24	0.78
1. Been upset	1.75 (1.09)	0.77		0.21	0.85
10. Could not overcome	1.80 (1.20)	0.75		0.13	0.90
6. Could not cope	1.78 (1.09)	0.71		0.22	0.83
9. Been angered	1.74 (1.24)	0.70		0.14	0.84
8. On top of things	1.91 (1.18)		0.78	0.25	0.91
7. Control irritations	1.74 (1.11)		0.66	0.24	0.84
5. Going your way	2.30 (1.17)		0.63	0.32	0.85
4. Felt confident	1.68 (1.23)		0.60	0.32	0.92
Eigenvalue		3.48	1.80		
Variance (Total = 89.5%)		65.6%	23.9%		
Inter-factor correlation			0.60		

SRW: standard regression weight

Table 3. Correlations between PSS-10 factors, Composite Reliability (CR), and Average Variance Extracted (AVE) (N=218)

Factors	1	2
1. Perceived helplessness	1	
2. Perceived efficacy	0.60	1
AVE	0.79	0.81
CR	0.94	0.88

CR: Composite reliability, AVE: Average variance extracted

Table 4 Correlations of PSS-10 and its two subscales with other variables (N=449)

Variables	1	2	3	4	5	6	7	8	9
1. PSS-10	1.00								
2. Perceived helplessness -sub	0.88**	1.00							
3. Perceived efficacy -sub	0.51**	0.09	1.00						
4.PDD	0.16**	0.14**	0.07	1.00					
5. PHQ-9	0.54**	0.54**	0.17**	-0.02	1.00				
6. GAD-7	0.62**	0.65**	0.14**	0.01	0.72**	1.00			
7.MSPSS-12	-0.22**	-0.13**	-0.24**	-0.31**	-0.11*	-0.09	1.00		
8.APGAR-5	-0.30**	-0.19**	-0.35**	-0.27**	-0.18**	-0.17**	0.56**	1.00	
9.CRF-12	-0.33**	-0.15**	-0.45**	-0.27**	-0.12**	-0.08	0.54**	0.66**	1.00

&Spearman correlation using pairwise deletion for missing values *P< 0.05, ** P<0.01

PSS: Perceived stress scale; PDD: Perceived Devaluation and Discrimination Scale; PHQ-9: Patient health questionnaire-9; GAD-7: Generalized anxiety disorder scale-7; MSPSS: Multidimensional scale of perceived social support; APGAR: Family adaptation, partnership, growth, affection, and resolve index scale; CRF: Caregiving rewarding feelings

FIGURE 1 | Standardized factor loadings for the two-factor model of the Perceived Stress Scale (PSS-10) (N=218) . F1: perceived stress; F2: perceived efficacy; pss: perceived stress scale.

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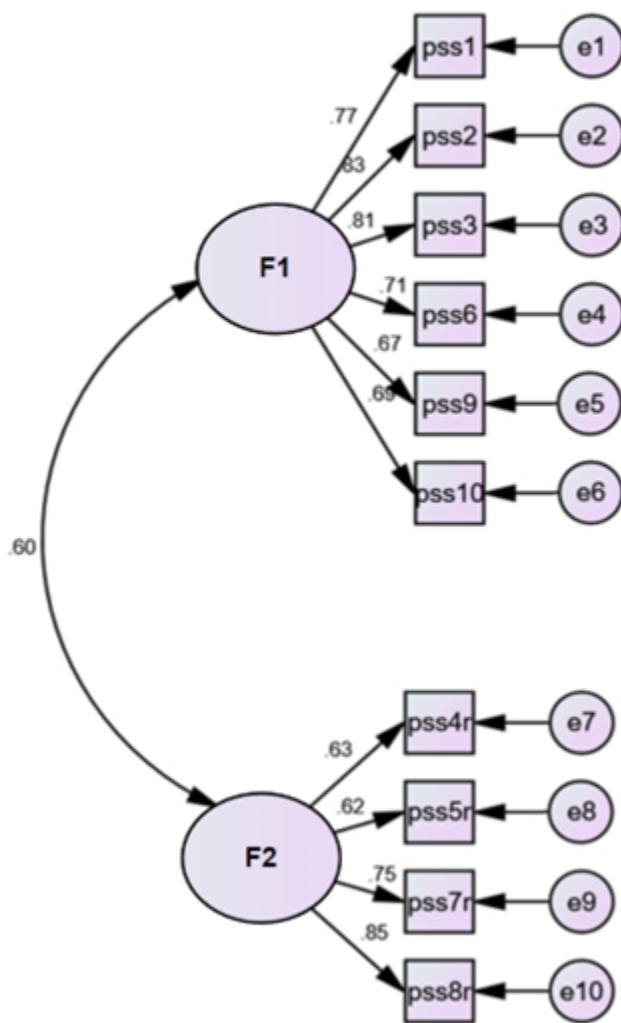


FIGURE 1 | Standardized factor loadings for the two-factor model of the Perceived Stress Scale (PSS-10) (N=218) . F1: perceived stress; F2: perceived efficacy; pss: perceived stress scale.

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60STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1-3
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3-5
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6-8
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8-9
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	8-9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	9-13
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	8-9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	13
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	13-14
		(b) Describe any methods used to examine subgroups and interactions	13-14
	(c) Explain how missing data were addressed	NA	
	(d) If applicable, describe analytical methods taking account of sampling strategy	NA	
	(e) Describe any sensitivity analyses	13-14	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	14
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	14
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	14-15

1 2 3 4 5 6 7 8 9 10	Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	NA
11 12 13			(b) Report category boundaries when continuous variables were categorized	14-15
14			(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
15 16 17 18 19	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	14-15
20 21 22 23	Discussion			
24 25 26	Key results	18	Summarise key results with reference to study objectives	18
27 28 29 30 31	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17-18
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-18
	Generalisability	21	Discuss the generalisability (external validity) of the study results	16-18
	Other information			
	Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.